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Experimental Study on High Performance Concrete by using Partial Replacement of Copper Slag and Fly Ash

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ABSTRACT

The conventional concrete has lost its usage nowadays as it does not set out the present need. The term 'High Performance' is because of the essential usage, materials and proportions of this concrete are specifically chosen for properties such as high workability, high density and low permeability. The main objective of this study is to deal with the effects of cementitious materials in High Performance Concrete (HPC) for mix design of M40 grade concrete. Hence, copper slag which is the industrial by-product is used as a partial replacement of fine aggregate by (0%, 15%, 30%, 45%, 60% and 75%) with 20% of fly ash by the volume of cement with water cement ratio 0.36. Super plasticizer conplast SP430 is used as chemical admixture at the rate of 1.2% of cement which improves the workability. From this experimental study, so far the utilization of copper slag and fly ash observed with gradual improvement in mechanical properties such as compressive, split tensile and flexural strength in HPC. By evaluating the optimum percentage of copper slag,

KEYWORDS: *Copper slag, Fly ash, HPC, Super plasticiczer*

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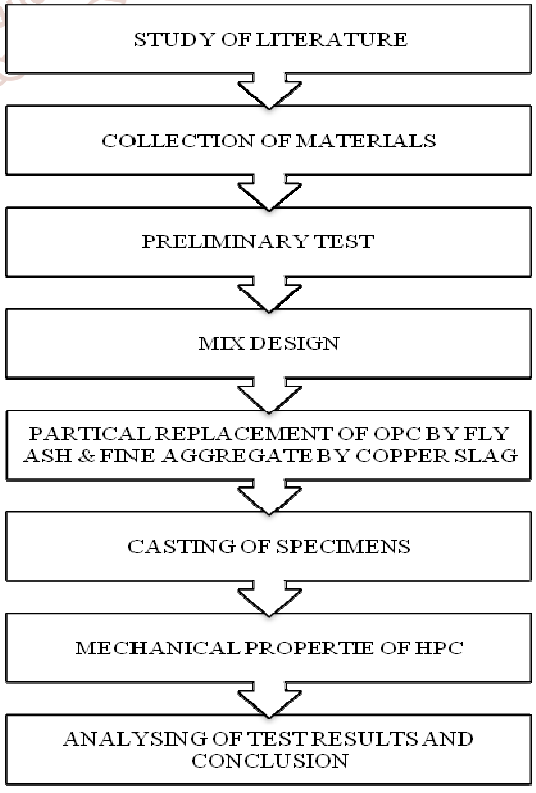
1. INTRODUCTION

Concrete is a composite material composed of coarse aggregate bonded together with the fluid cement that hardens cement binder. Nowadays, many studies are going on for increasing the properties of conventional concrete. High performance concrete (HPC) is a concrete mixture, usually enhance the strength, durability and workability qualities to a very high extent when compared to conventional concrete. It is made with carefully selected high-quality ingredients and optimized mixture designs. It is generally essential to use chemical and mineral admixtures in addition to the same ingredients of normal concrete. The supplementary cementing materials are usually added at dosage rates of 5% to 20% or higher by mass of cement. It will have a low water-cementing materials ratio of 0.20 to 0.45. Super plasticizer is an important ingredient in HPC in order to provide good workability and consistency for the concrete matrix. It is always has a higher strength than normal concrete. However, strength is not the primary required property because a normal concrete with high durability and low permeability is considered as high performance properties.

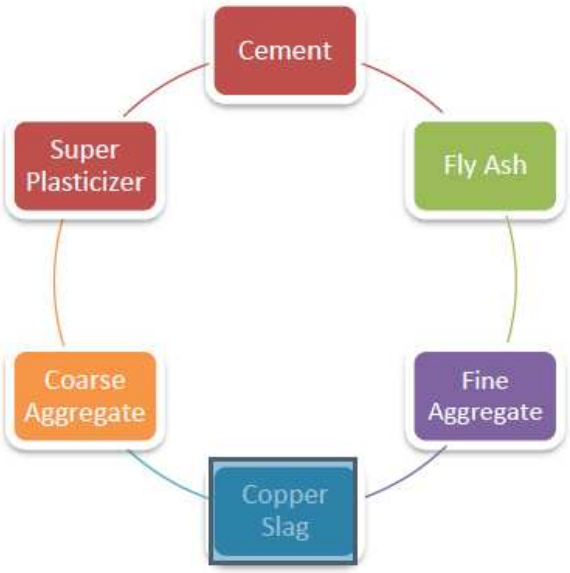
To investigate the feasibility of using copper slag as filler material and fly ash as an admixture in concrete and to determine the optimum value of copper slag replacement in HPC for M40 grade concrete.

2. METHODOLOGY OF THE WORK

2.1. FLOWCHART OF THE STUDY



3. MATERIAL COLLECTION



3.1. CEMENT

The experiment uses Ordinary Portland Cement (OPC) 53 Grade conforming to IS 12269 is used for casting concrete. Specific gravity is 3.15, fineness and consistency is 1.4% and 32 %.The tests of cement should be conducted as per IS 4031 (Part 5).

3.2. FINE AGGREGATE

It is natural sand or crushed stone with most particles through 9.5mm sieve. Specific gravity is 2.6 and fineness modulus was found out Zone (II) is 2.66. The tests are carried out as per IS 2386 (Part 3).

3.3. OARSE AGGREGATE

It consists of naturally occurring stones. The size of coarse aggregate used was 20mm.Specific gravity is 2.65 and water absorption is 1%. The tests are carried out as per IS 383-1970.

3.4. COPPER SLAG

Copper slag is an irregular, black, glassy and granular in nature which is by-product obtained during the metallurgical operations in furnaces of copper industries. The physical properties are similar to natural sand. Al2O3, SiO2, Fe2O3, about major therefore have good potential to produce high quality Pozzolonic content. Copper slag. used in this project is collected from ASTRAA Chemicals, Chennai. The Physical properties and chemical properties of copper slag are given in the Table

Fig. 1 Copper Slag

Table: 1 Physical & Chemical properties of Copper slag

Parameter	Value
Type	Air cooled
Grain size	Multifaceted
Specific gravity	3.41
SiO2	33 – 35
Fe2O3	40 – 44
Al2O3	4.0 -6.0
Mgo	1 – 2
Cao	0.8 – 1.5

3.5. FLY ASH

Fly ash is a fine-grained, Powderly particulate pozzolonic in nature produced from thermal power plant. The burning of harder and bituminous coal typically produces Class F fly ash. It is used in this study is collected from Neyveli Lignite Corporation (NLC). The Physical properties and chemical properties of fly ash are given in the Table.

Fig.2 Fly Ash

Table2 : Physical &Chemical Properties of Fly ash

Parameter	Value
Specific gravity	2.1
Fineness modulus	2.16
SiO2	63.11
Al2O3	19.58
CaO	17.13
Fe2O3	5.03
L.O.I	1.55

4. EXPERIMENTAL DETAILS Mix design and Identification

In this study, M40 grade of concrete for HPC is designed in accordance with the guidelines of code book IS 10262:1982. The mix ratio is **1: 1.18: 2.4 (C: FA: CA)** and **w/c ratio is 0.36** is adopted. Copper slag is added at varying percentages of 0%, 15%, 30%, 45%, 60% and 75% by replacing fine aggregate (FA) with 20% of Fly ash by the volume of cement. Each mix is denoted by M, in which M1 represents the conventional mix and from M2 to M6, cement is replaced by 20% of fly ash and FA by 0-75% of CS.

Table3: Mix Proportion

S.No	Mixing details	Mix No	Partial replacement of Cement (%)		Partial replacement of Fine aggregate (%)		Sp (%)
			OPC	Fly ash	FA	CS	
1	Control	M_1	100	0	100	0	0
2.	Binary Cement Mixes	M_2	80	20	75	15	1.2
3.		M_3	80	20	60	30	1.2
4.		M_4	80	20	55	45	1.2
5.		M_5	80	20	40	60	1.2
6.		M_6	80	20	25	75	1.2

4.1. CASTING OF SPECIMEN

The moulds for the specimen must be made of cast iron or steel. For most of the works Cubical moulds of size 150mm x 150mm x 150mm, Cylinder 300mm height and 150mm diameter and then flexural 100x100x500mm are commonly used.

Fig.3 Casting Of Specimen

4.2. TESTING OF SPECIMEN

It has been carried out to the specimens to ascertain the mechanical related properties deals with Compression and Split tensile strength of concrete specimens are done to find, the most efficient combination of copper slag and fly ash with chemical admixture dosage of 5.72 kg/m3.

Fig4. Compressive Strength testing of Cube

5. RESULTS

Table: 4 Compressive Strength Results

S.No	Mixing details	Mix ID	Compressive strength (N/mm²)	
			7 days	28days
1	Control	M_1	27.5	43
2	Binary Cement Mixes	M_2	30.5	45.8
3		M_3	34.4	48.1
4		M_4	40	52.2
5		M_5	33	47
6		M_6	25.5	42

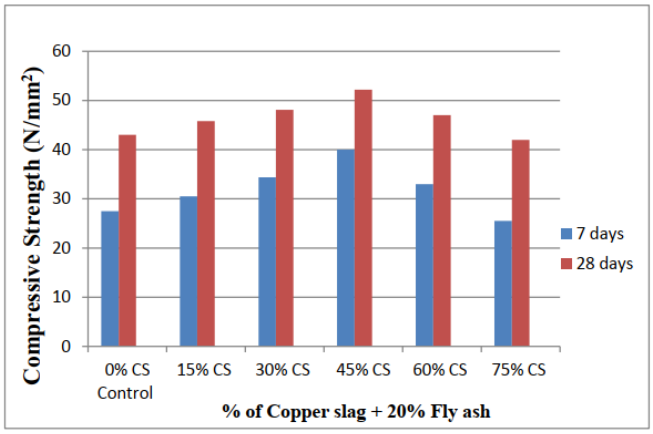


Fig.4 Compressive Strength Results

Table: 5 Split Tensile Strength Results

S.No	Mixing details	Mix ID	Split tensile strength (N/mm²)	
			7 days	28days
1	Control	M_1	2.8	3.5
2	Binary Cement Mixes	M_2	3.1	3.83
3		M_3	3.35	4
4		M_4	3.7	4.4
5		M_5	3.2	3.7
6		M_6	3	3.3

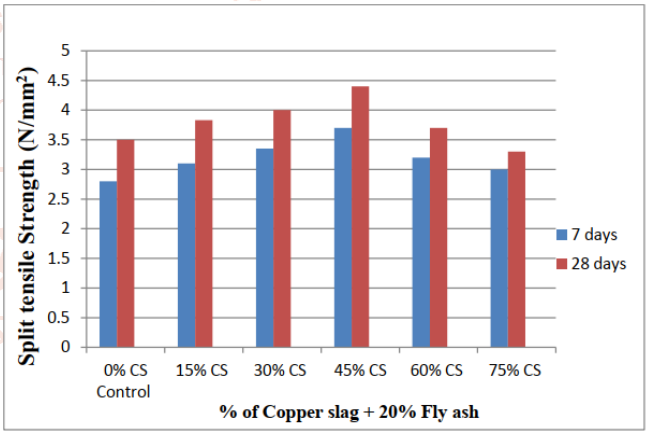


Fig. 5 Split tensile strength results

6. CONCLUSION

1. Copper Slag is considered as a waste material which could have a promising future in construction industry as partial or full replacement of either cement or aggregates.
2. Through this study it is found that, there is improvement in strength of HPC compared to conventional concrete due to presence of copper slag, fly ash and chemical admixture there is an increase in the strength of concrete.
3. The strength of the specimens after 7 and 28 days, the mix M4 attained compressive strength of 40 and 52.2 N/mm2 and then split tensile strength of 3.7 and 4.4 N/mm2 split tensile strength.
4. While comparing the results with conventional concrete the optimum percentage obtained in 45% copper slag and 20% fly ash with Super plasticizer dosage of 5.72 kg/m3.

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